STAR TPC coordinate transformations (T0?)

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STAR TPC coordinate transformations.

- STAR TPC coordinate system transformations (StTpcCoordinateTransform class) have introduced 21 years ago by D. Hardke(, M. Calderon, B. Lasiuk, …) and consists of
  - StGlobalCoordinate (**G**): the coordinate system (CS) defined by the STAR magnet,
  - StTpcLocalCoordinate: the TPC CS surveyed with respect to the STAR magnet,
  - StTpcLocalSectorCoordinate, StTpcLocalSectorAlignedCoordinate (**L**): Sector 12 CS with X in pad direction, Y in row direction, and Z as drift distance from Gating Grid.
  - StTpcPadCoordinate: (sector, row, pad, time bucket)

The coordinate transformation from measurement in local sub sector coordinate (**L**) to the STAR global coordinate system (**G**) is expressed a product of 4x4 matrices (ROOT::TGeoHMatrix)

$\mathbf{G = R_{TPC} \times (T_{wheel} \times R_{wheel}) \times (R_{sector} \times \Delta R_{sector}) \times R_{flip} \times \Delta R_{inner,outer} \times L}$,

$\mathbf{R_{TPC}}$ is the surveyed position of TPC in STAR magnet (StTpcPosition),

$\mathbf{T_{wheel}}$ is translation of in Z direction by $\pm Z_{GG}$ for the West and East halves of TPC, respectively, where Z_{GG} = 208.707 cm is the Gating Grid position.

$\mathbf{R_{wheel}}$ is the surveyed position of West and East wheel in TPC,

$\mathbf{R_{sector}}$ is the ideal sector position in TPC half,

$\mathbf{\Delta R_{sector}}$ is the super sector misalignment,

$\mathbf{R_{flip}}$ is conversion (x,y,z) ⇒ (y,x,-z) from local sector coordinate system to sector one,

$\mathbf{\Delta R_{inner,outer}}$ is inner / outer sector misalignment,

L is the local sector coordinate as result of transformation of (pad, row, time backet) ⇒ (x, y, z ≡ drift distance).

The alignment procedure is a way to find $\mathbf{\Delta R_{sector}}$ and $\mathbf{\Delta R_{inner,outer.}}$

Before **iTPC** era we assumed that $\mathbf{\Delta R_{inner} = I}$, i.e. we did only alignment of $\mathbf{\Delta R_{outer}}$.

After **iTPC** was install we froze the previous $\mathbf{\Delta R_{outer}}$, and did alignment of $\mathbf{\Delta R_{inner}}$.

ΔR is defined as product on translation (δx, δy, δz) and rotations (α around X, β around Y, γ around Z).

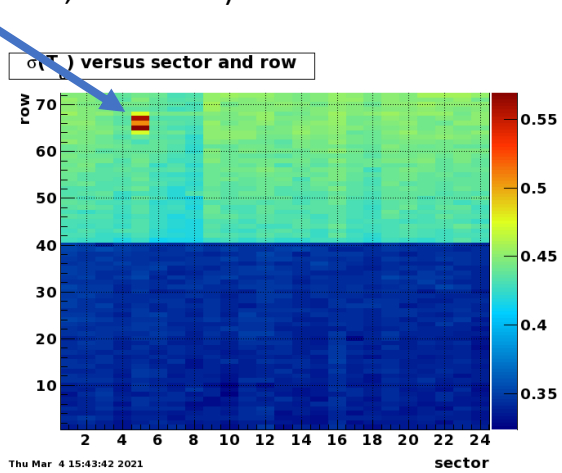
- StTpcCoordinateTransform takes care about transformation between the above coordinate systems.

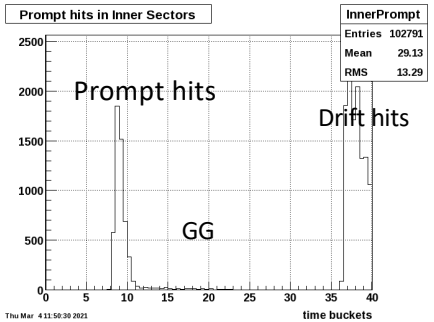
StTpcPadCoordinate ⟷ StTpcLocalSectorCoordinate

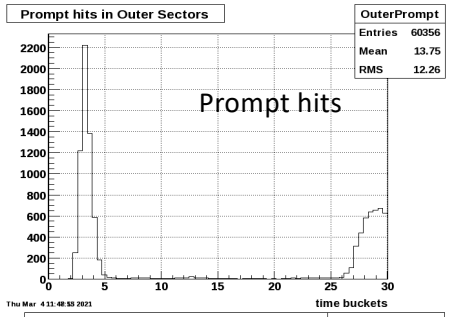
- StTpcCoordinateTransform::xFromPad(Int_t sector, Int_t row, Double_t pad):
  - x_{Pad} = -pitch*(pad - (npads+1.)/2.), using pad pitch and no. of pads per row from tpcPadPlanes (pitch$_{Inner}$ = 0.335 cm and pitch$_{Outer}$= 0.67 cm) or itpcPadPlanes tables (pitch$_{iTPC}$ = 0.5 cm) from Geometry/tpc database.
  - For iTPC it is also applied Jim Thomas' pad survey correction, a small shift, rotation and stretch from iTPCSurvey table from the same database.
- StTpcCoordinateTransform::zFromTB(Double_t tb, Int_t sector, Int_t row, Int_t pad)
  - z = **DriftVelocity**(sector,row)*1e-6*time, // drift distance from the Gating Grid
  - time = t0 + tbx*__mTimeBinWidth__,
  - tbx = tb + St_tpcSectorT0offsetC::instance()->**t0offset**(l), l = sector for Outer and sector+24 for Inner Sectors. **These are offsets defined from the prompt hit time position.**
  - For sectors where it was observed a deviation the above offsets for different **RDO** an additional correction is applied
    tbx += St_tpcRDOT0offsetC::instance()->T0(sector,row,pad);
  - t0 = trigT0 + elecT0 + sectT0
    - trigT0 = StTpcDb::instance()->triggerTimeOffset()*1e6 = St_trgTimeOffsetC::instance()->**offset**(); // table trgTimeOffsetB in Conditions/trg, trigT0 = 2.372249 μsec for Run XIX. **This T0 is measured by difference in Z position of reconstructed primary vertices tracks reconstructed in the West and East Tpc only.**
    - elecT0 = StTpcDb::instance()->Electronics()->tZero() = St_tpcElectronicsC::instance()->**tZero**(); // tpcElectronicsB in Calibrations/tpc, elecT0 = -0.1190 μsec and frozen for Runs > Run XIII
    - sectT0 = St_tpcPadrowT0C::instance()->T0(sector,row) = 0; // disabled with new Tpc Alignement
  - mTimeBinWidth = 1./StTpcDb::instance()->Electronics()->samplingFrequency() = 1./(1e-6*St_starClockOnlC::instance()->**CurrentFrequency**()) // starClockOnl table from RunLog/onl database
- StTpcCoordinateTransform::operator()(const StTpcPadCoordinate& a, StTpcLocalSectorCoordinate& b, Bool_t useT0, Bool_t useTau):
  - z = zFromTB(a.timeBucket(),a.sector(),a.row(),a.pad())-zoffset+t0zoffset
  - zoffset = StTpcDb::instance()->Dimensions()->**z[Inner|Outer]Offset**() = St_tpcEffectiveGeomC::instance()->**z_[inner|outer]_offset();** // tpcEffectiveGeomB table from Calibrations/tpc; Effective distances from the Gating Grid to anode wires ("**extra drift distance**") : 1.22 cm for Inner and 1.69 cm for Outer sectors, respectively. These values have been estimated from **Garfield.**
  - t0zoffset = -3 **τ** * DriftVelocity; // The shift cluster position from the average to begin of cluster due to electronics shaping time (**τ** = 0.055 μsec).

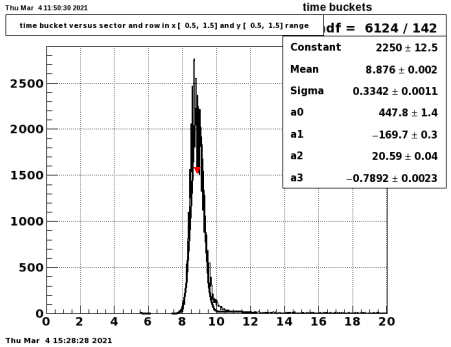
Sector time offsets from the prompt hit time positions (7p7GeV_2021)

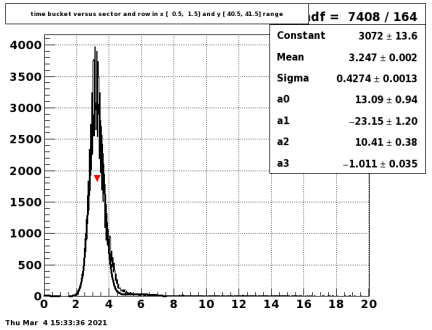
- The prompt hits are created by particles directly in active gas volume near anode wires and they are not affected by Gating Grid (GG).
- By fitting the histograms for each sector and row with Gauss + pol3 we can measure the most probable position(μ) and σ.
- Averaged over rows <μ> (= T_0) gives us correction in order to adjust timing for outer and inner sectors.
- Significant deviation of σ from averaged value has pointed that there are some T_0 variations on the level of RDO (sector 5, row 64-68).

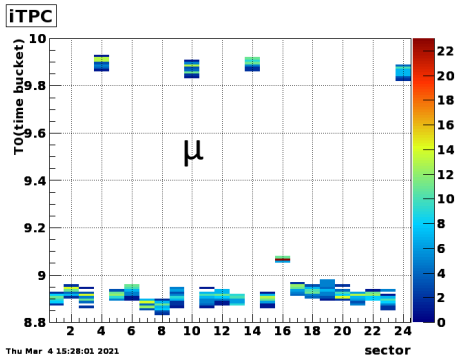


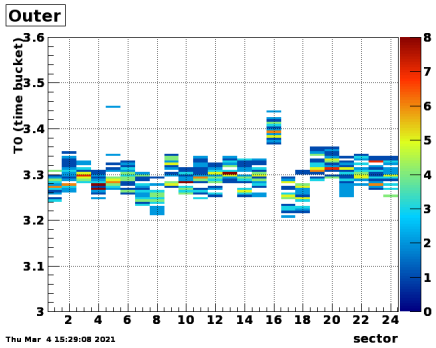












Prompt hit position in Tpc Sector Local Coordinate System

Anode wire position in GG CS:

Inner: -0.8 cm

Outer: -1.0 cm

Electrons drift in between GG and anode wires in varying electric field with different from “nominal” drift velocity. The drifting time can be converted to “extra drift distance” with “nominal” drift velocity. This extra drift distance is added to total

Garfield:

Extra drift from GG to anode wires

Inner : 1.22 cm

Outer : 1.69 cm

Difference 0.47 cm

(The extra drift correction is applied for all hits. For prompt hits it should not be applied: subtract).

Garfield:

Prompt hit collection time:

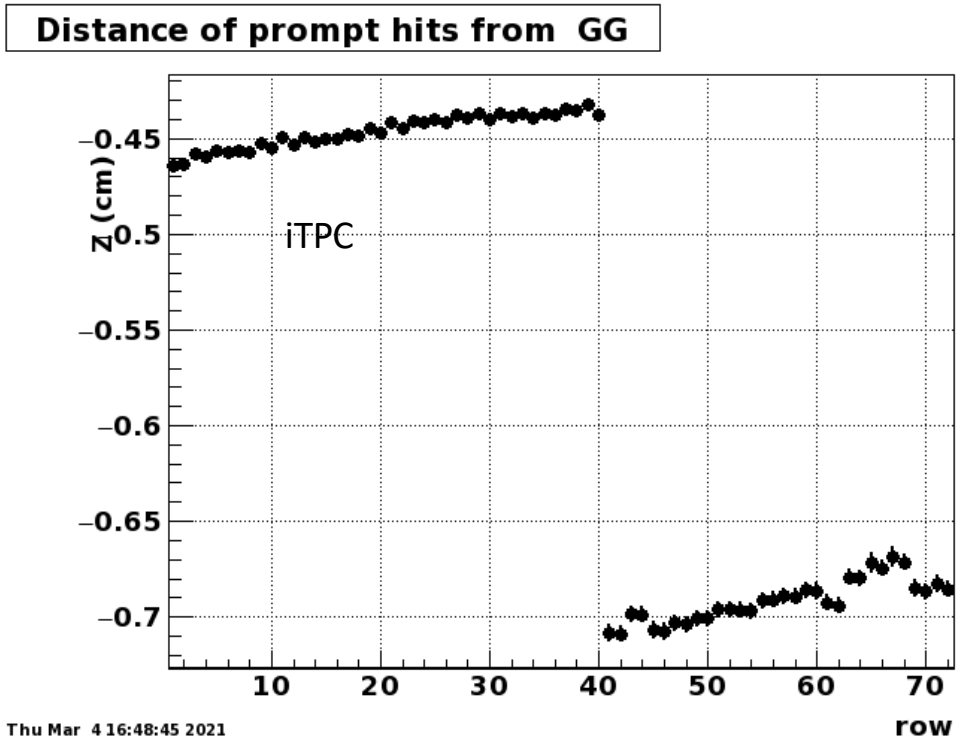
Inner : 0.32 cm

Outer : 0.53 cm

Difference : 0.19 cm

Total Difference in local Z for prompt hits :

0.47 – 0.19 = 0.28

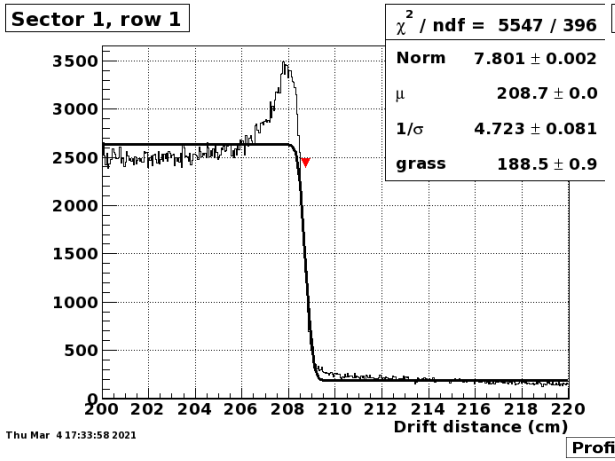


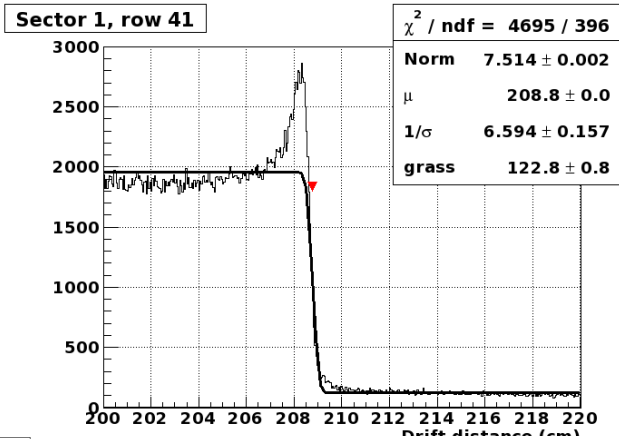
Membrane

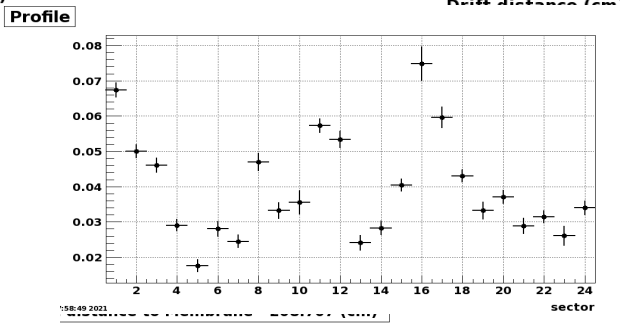
In order to have another reference we can use a charge step at the Central TPC Membrane. In Tpc Sector CS membrane is at Z == drift distance = 208.707 cm.

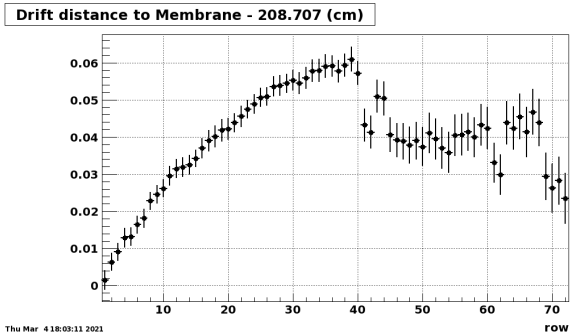
For each sector and row, the charge step has been fitted by freq function + grass. Example of the fit are shown.

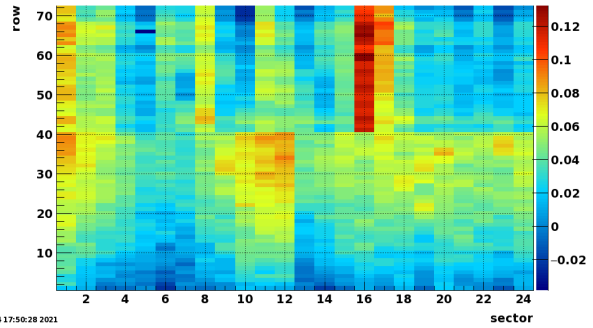
1. On color plot we see some structure for sector 16 which we should take care of.
2. The precision finding of membrane is ~600µm
3. There is a strange dependence of row for iTPC.
4. …











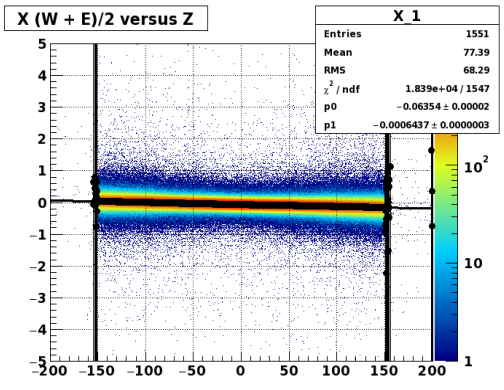
The global timing

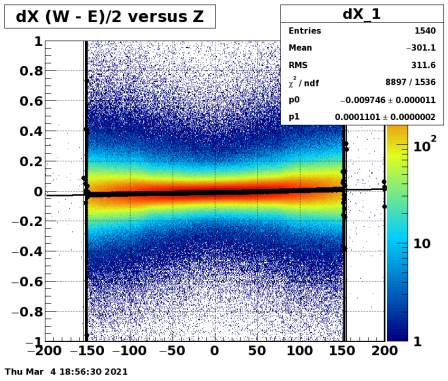
- The main tool is reconstructing primary vertex from from tracks reconstructed only
  - in West part of TPC and
  - in East part of TPC

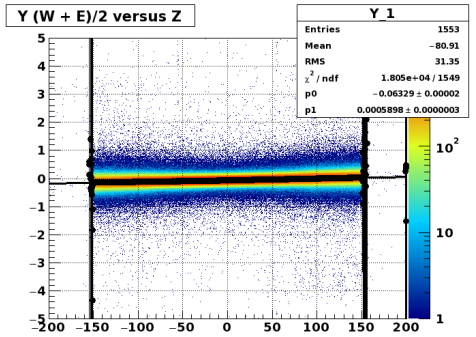
with KFParticle.

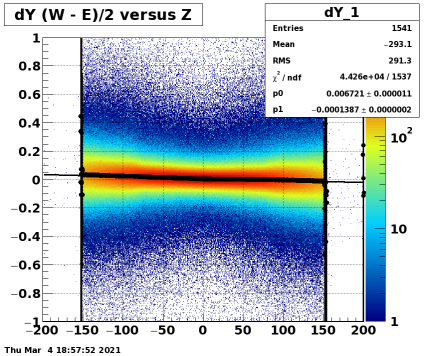
Using difference between West and East coordinate the global timing can be reconstructed as dT difference at Z = 0.

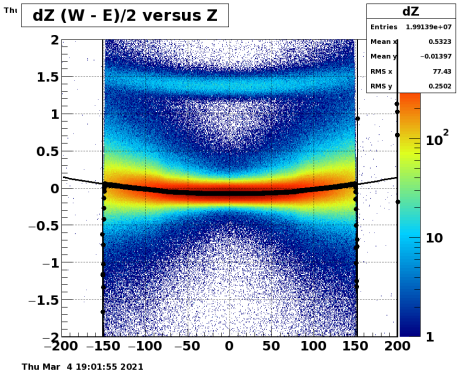
The presence of the 2nd band in dT/dZ is a surprise for me. I don't know what is that.

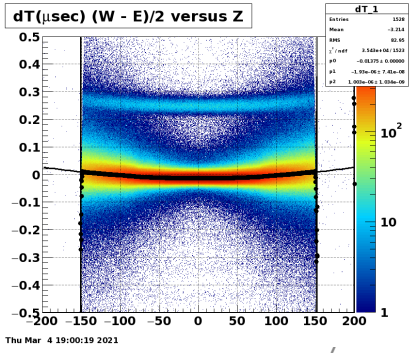






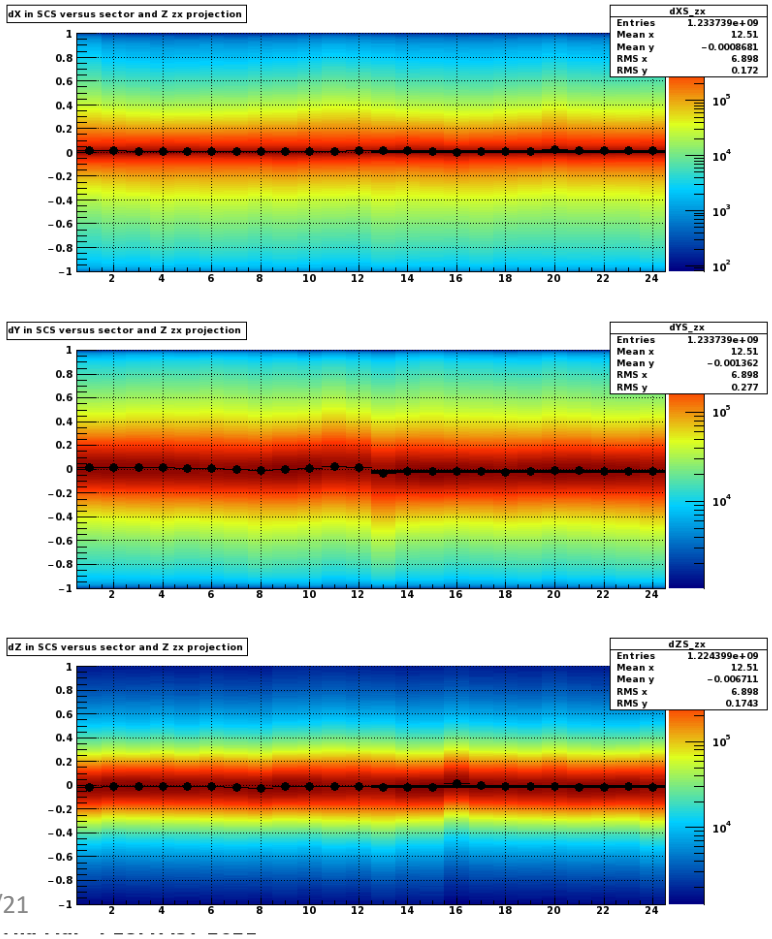






Reverse Full Field versus Forward Full Field. I do see an effect.

RF



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